Title: **Examining Treatments Used on Colorado Spruce to Maintain Postharvest Quality**

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FINAL STATUS OF THE PROJECT

Experimental Technique:

The experiment, examining fertilizer treatments used on 5 to 6 ft tall balled and burlapped plants of Colorado spruce while being held in a mulch bed, began when the trees were received in early May 2002. Sixty of the most uniform trees were selected out of the 70 trees received. Extra trees were used as a guard row. Most of the balled trees used in the study had 24-inch root balls. The trees were evaluated over the next two weeks, and those chosen for the experiment were randomly assigned to one of five treatments in one of four blocks. The mulch bed was 30 feet by 94 feet (Figure 1). On June 4, initial tree heights and trunk diameters (at 20 cm above the root ball) were measured. Fertilizer treatments were applied on June 6, to begin the experiment. The fertilizer treatments included a control (pine bark without fertilizer), Osmocote 15-9-12 distibuted over the top of the ball at 114.2 grams (label rate) per root ball, Miracle·Gro® 12-10-10 Evergreen Fertilizer spikes, one-half cartridge of Ross Root Feeder® 10-12-12 evergreen fertilizer injected into the root ball at four points, and a 50:50 mixture (by volume) of Eko Compost mixed with pine bark. Pine bark mulch covered the bottom and sides of the root balls, but the tops were left uncovered to prevent watering problems. Plants were watered by hand and overhead sprinklers until a drip irrigation system was completed by June 18.

Figure 1. Colorado spruce trees heeled into a 30 ft. by 94 ft. bed. The root balls are surrounded by fresh pine bark mulch.

Soil samples were taken from each root ball on June 4 so that initial soil nitrogen levels and microbial nitrogen levels could be determined. A second set of soil samples was taken on August 30, and a third set was taken on October 30. On June 4, about three inches of growth from three branches (the previous year's growth) were removed from each tree and dried in a drying oven at 70°C for three days. After drying, needles were removed from the stems and ground before being sent for foliar mineral analyses. Foliar samples were taken from three branches of the current season's growth (2002) from the trees on November 8, and foliar samples were again handled in the same manner. Final tree heights and trunk diameters at the end of the season were measured on October 25. The effects of the fertilizer treatments on changes in tree height and trunk diameter by the end of the growing season were analyzed by analysis of variance. Foliar nutrient levels as affected by fertilizer treatments and changes in needle nutrient levels by the end of the growing season were also analyzed by analysis of variance. Significant differences between treatment means were determined by Least-square means at the 5% level. Means and standard deviations for levels of soil nitrogen and microbial biomass nitrogen in the soil were also determined.

Results and Discussion:

On July 5 during a routine inspection, we noticed purple colored needles on the southwest sides about half of the trees. Only the one-year-old needles became discolored on some southwestern branches. After some phone calls, we determined the problem may have been too much water applied, so watering was reduced and a fungicide Bravo Weather Stick® was applied in case needle discoloration was due to Rhizosphaera needle cast. After two weeks of reduced water, both new and old needles on several branches all around the plants began to die, mainly on the lower branches. Two Idaho nursery growers of Colorado spruce examined the trees. Based on their evaluations, the problems with the trees appeared to be tied to a number of factors. The high temperatures in early July along with needing more water apparently caused the strees. Four trees that were received died. Two trees were in the guard row and two trees died in the experiment. The root system of all four trees was carefully examined and found to be sparse. Hence, they tree mostly died due to heat stress and insufficient root systems along with needing more water applied while they were held in the mulch bed. At least two of the dead trees had bores in their trunks, an indicator that at least two of the trees were stressed before they were shipped. Even though almost every tree in the experiment suffered some heat damage and water stress, the health of the trees stabilized by early August. The experiment was continued and data taken as described above.

Changes in tree height and trunk diameter by the end of the growing season (as determined by percentages of change from initial measurements) were unaffected by the fertilizer treatments applied to the root balls in June (Table 1). Apparently, the fertilizer treatments had little effect on the tree growth over the summer. Most likely the trees were strongly influenced by transplant shock and so they grew only a minimal amount despite being fertilized (compare the change in of growth – height and diameters – of control {without fertilizer} versus fertilized plants). Therefore, the fertilizer treatments failed to improve tree growth during the first growing season after digging.

A composite soil sample was made by sampling ten root balls at random to a six-inch depth. The grower did not fertilizer the field, and part of the reason the trees were purchased from this particular grower was because we thought the fertilizer would have an immediate impact on the spruce trees. The initial mineral levels in the composite soil sample were relatively good. The soil pH was 6.6, and the percent organic matter was 4.5. The concentration of nitrate-N was 29 parts per million (considered good); P was 34 ppm (considered moderate); exchangeable K was 157 ppm (considered high); exchangeable Mg was 162 ppm (considered high), exchangeable Ca was 1187 ppm (considered moderate); exchangeable Na was 27 ppm (considered very low); S was 15 ppm (considered moderate); Zn was 2.6 ppm (considered moderate); Mn was 23 ppm (considered high); Fe was 72 ppm (considered very high); Cu was 1.5 ppm (considered high); and B was 0.5 ppm (considered low). Overall, this soil was considered to be fertile and had adequate levels of minerals for Colorado spruce trees.

Table 1. Percentage changes in tree heights and trunk diameters as affected by fertilizer treatments applied to the root balls of Colorado spruce trees. Trunk diameters were measure at 20 inches (51 cm) above the root ball. Initial measurements were made in June and final measurements in October.

Treatment	Change in tree height[z] (%)	Change in trunk diameter[y] (%)
Bark control	3.7	5.3
Osmocote 15-9-12	5.3	5.7
Fertilizer spike 12-10-10	3.8	7.8
Injected fertilizer 10-12-12	6.3	5.4
50:50 Compost:bark mix	6.2	6.8

[z] Change in tree height was calculated by comparing the change in height over the growing season divided by the initial height: height change = (final hgt.– initial hgt.)/ initial hgt.

[y] Change in tree diameter was calculated by comparing the change in diameter over the growing season divided by the initial diameter: diameter change = (final diam. – initial diam.)/ initial diam.

The foliar nutrition data reveal some interesting information. First, foliar mineral levels in foliage taken in spring are unaffected by the fertilizer treatment with the exception of Fe levels in the needles (Tables 2 and 3). This result makes sense since the fertilizers were applied after foliar samples were taken. The Fe levels in needles are fairly consistent except for the needles taken from control plants (Table 3). This result may be an aberration. The fertilizer treatments affected mineral nutrition of only foliar N, Mg, Ca, S, and B in the fall (Tables 2 and 3). Needles from trees treated with the mixture of 50:50 compost:bark usually had the highest levels of these five minerals. Needles from trees treated with the Miracle Gro fertilizer spike usually contained the second highest levels of these four minerals. Trees treated with 15-9-12 Osmocote had significantly higher levels of B in their needles compared to the controls as well (Table 3). Based on these data, the compost mixture and fertilizer spike appeared to supply the Colorado spruce trees with the most N, Mg, Ca, S, and B, with the compost being the most effective in supplying these minerals.

Table 2. Percentages of minerals in needles from Colorado spruce trees treated with different fertilizers. Data within a column followed by a different letter are significantly different at the 5% level.

	%N		%P		%K		%Mg		%Ca		%S	
Treatment	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall
Control	1.0	1.2 c	0.2	0.4	0.4	0.8	0.12	0.10 b	1.0	0.3 b	0.09	0.10 b
Compost	1.0	1.5 a	0.2	0.4	0.4	0.9	0.12	0.14 a	1.0	0.4a	0.08	0.13 a
Osmocote	1.0	1.2 c	0.2	0.4	0.4	0.8	0.12	0.11 b	0.8	0.3 ab	0.08	0.10 b
Injection	1.0	1.3 ab	0.2	0.4	0.4	0.8	0.11	0.10 b	0.9	0.2 b	0.08	0.10 b
Spike	1.0	1.4 ab	0.2	0.4	0.4	0.8	0.12	0.12 ab	0.9	0.3 ab	0.09	0.13 a

Table 3. Parts per million of minerals in needles from Colorado spruce trees treated with different fertilizers. Data within a column followed by a different letter are significantly different at the 5% level.

	Fe (ppm)		Mn (ppm)		B (ppm)		Cu (ppm)		Zn (ppm)	
Treatment	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall	Spr	Fall
Control	152 a	133	394	220	6.8	2.2 b	3.4	2.1	52	29
Compost	116 b	159	391	337	6.2	4.6 a	3.3	2.8	49	34
Osmocote	114 b	163	467	229	6.2	3.5 a	3.3	2.7	50	32
Injection	111 b	154	382	193	6.0	2.9 b	3.1	2.3	49	26
Spike	126 b	146	453	297	6.2	3.7 a	3.5	2.8	49	28

Differences between initial and final foliar nutrient levels were also examined to determine if the fertilizer treatments affected the changes over the growing season. The fertilizer treatments effected changes of only three nutrients in the Colorado spruce needles (Table 4). Needles from trees receiving the compost treatment had the highest changes of N concentrations. The fertilizer spike and compost resulted in the highest levels of changes for S and Mn. The negative numbers for percentage Mn changes means that the concentrations of Mn in the needles at the end of the season were lower than they were at the beginning of the growing season. Even so, needles from compost treated trees had the least amount of negative change, indicating Mn levels after one season in the mulch bed were closer to those levels in needles at the start of the experiment. One other point worth noting is that even though the statistical models were nonsignificant, needles from trees treated with compost had higher positive changes for K, Mg, Fe, and B (data not shown). Without the statistical model being significant ($P < 0.05$), however, these data can only be considered trends.

Table 4. Percentage changes in nutrient level of Colorado spruce needles treated with different fertilizers. Data within a column followed by a different letter are significantly different at the 5% level.

Treatment	% Change N	% Change S	% Change Mn
Control	15.6 c	16.3 b	- 44.2 b
Compost	55.0 a	54.3 a	- 7.2 a
Osmocote	22.9 bc	23.8 b	- 46.7 b
Injection	27.1 bc	19.5 b	- 48.1 b
Spike	37.6 b	46.1 a	- 28.9 ab

Some foliar nutrient levels increased by the end the growing season whereas other decreased by November, regardless of the fertilizer treatment used (Tables 2 and 3). These overall foliar concentrations in June versus October were not compared statistically, but they are of interest. For instance, N levels increased in needles from trees receiving two treatments. The levels of P, K, S, and Fe in the needles seemed to increase, regardless of the fertilizer treatment used. In contrast, the concentrations of Ca, Mn, B, and Zn in needles decreased regardless of the treatments used. We speculate that the increases indicate that the bark mulch supplied some minerals that were less available in the field soil. On the other hand, the bark mulch lacked certain minerals and so these levels were lower in the needles by the end of the growing season. Even with the decreases, only the reduced levels of Ca in the needles seemed to be near mineral deficient levels.

The mineral nitrogen content of soil in the root balls appeared to be unaffected by the fertilizer treatments (Table 5). The mineral nitrogen content seemed to change with the season, with ammoniafication and nitrification of nitrogen being highest during the August and low in June and October. The fertilizer treatments also appeared to have little influence on the amount of nitrogen tied up in soil organic matter in the root balls (Table 6). The amount of dissolved organic nitrogen appeared to be low during the three sampling times. Although the data were variable, the amount of nitrogen held by microbes in the soil seemed highest in June and August. This result makes sense since microbes would grow best when the soil temperatures were the warmest.

Table 5. Mineral nitrogen content (consisting of NH_4^+ and NO_3^-) of soil in root balls of Colorado spruce trees as affected by fertilizer treatments used. The roots balls were sampled three times (June, August, and October) during the growing season. Data are means $\pm$ their standard deviations.

Treatment	June-NH_4	Aug.-NH_4	Oct.-NH_4	June-NO_3	Aug.-NO_3	Oct.-NO_3
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	**(ppm)**
Control	1.8 $\pm$ 2.0	5.0 $\pm$ 3.5	1.4 $\pm$ 1.6	1.0 $\pm$ 1.7	5.6 $\pm$ 9.0	**3.2 $\pm$ 4.1**
Compost	3.6 $\pm$ 2.8	3.8 $\pm$ 1.2	1.7 $\pm$ 1.3	2.2 $\pm$ 2.8	10.3 $\pm$ 12.1	**4.0 $\pm$ 4.6**
Osmocote	1.8 $\pm$ 0.8	3.6 $\pm$ 3.3	2.4 $\pm$ 3.4	1.6 $\pm$ 2.6	18.2 $\pm$ 15.3	**3.0 $\pm$ 3.2**
Injection	1.9 $\pm$ 0.9	3.6 $\pm$ 2.3	2.3 $\pm$ 2.3	1.9 $\pm$ 2.7	8.9 $\pm$ 11.6	**1.2 $\pm$ 1.4**
Spike	**1.8 $\pm$ 0.8**	**4.9 $\pm$ 2.8**	**2.0 $\pm$ 2.1**	**0.4 $\pm$ 0.9**	**12.0 $\pm$ 17.8**	**2.1 $\pm$ 2.3**

Table 6. Organic nitrogen content (consisting of Dissolved Organic Nitrogen and Microbial Biomass Nitrogen) of soil in root balls of Colorado spruce trees as affected by fertilizer treatments used. The roots balls were sampled three times (June, August, and October) during the growing season. Data are means ± their standard deviations.

Treatment	June-DON	Aug.-DON	Oct.-DON	June-BMN	Aug.-BMN	Oct.-BMN
	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	**(ppm)**
Control	0.2 ± 0.5	1.4 ± 3.1	0	4.9 ± 6.0	5.6 ± 9.2	**0.2 ± 0.6**
Compost	0	1.2 ± 3.6	0.7 ± 1.4	2.4 ± 3.6	0	**0.2 ± 0.8**
Osmocote	0.6 ± 1.8	0	0	4.1 ± 4.4	0.3 ± 1.0	**0**
Injection	0	0.5 ± 1.1	0.5 ± 1.1	3.0 ± 4.9	3.0 ± 7.0	**0.6 ± 1.4**
Spike	**0**	**0.3 ± 0.6**	**0.3 ± 0.6**	**7.3 ± 7.8**	**0.1 ± 0.3**	**1.1 ± 2.2**

Significance to the Nursery Industry:

The fertilizer treatments used in this study did appear to improve foliar nutrition of the newly harvested balled and burlapped Colorado spruce trees. Overall, the compost seemed to increase levels of certain nutrients in the needles, particularly N. The fertilizer spike also helped increase foliar mineral concentration but to slightly lesser extent than the compost treatment. Tree growth, as determined by increase in height and stem diameter, were unaffected by the fertilizer treatments. This result may have been a consequence of transplant shock, but the heat and water stress suffered by these trees may have also affected the growth. Indeed, the heat and water stress could have also affected foliar mineral nutrition. For this reason, this study should be completed a second time to ensure that the data trends we saw from the 2002 experiment hold true when trees are held without losing their needles due to high temperatures and low water availability.